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SHAPE OF THE RED AND GREEN COLOR ZONE GRADIENTS

by

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SUMMARY PAGE

THE PROBLEM

To determine how far out from the fixation point red and green are seen and how visual sensitivity changes in this region. (Red and green can be seen only in a limited area around the fixation point.)

FINDINGS

The color zone limit for green is narrow, defining a relatively clear-cut zone of color competence with a border of irregular sensitivity. The color zone for red is not sharply defined and sensitivity extends irregularly, but reliably, into the far periphery.

APPLICATION

Plotting of color zones is used clinically as a diagnostic technique. In order to best utilize such a technique, knowledge of the nature of these zones is necessary. This study, by quantitatively defining sensitivity to red and green in the periphery, facilitates the determination and interpretation of abnormalities in the limits of vision.

ADMINISTRATIVE INFORMATION

This investigation was undertaken as a part of Bureau of Medicine and Surgery Task MR005.14-1001, under Subtask (1), Psychophysiological Studies of Visual Factors in Submarine Operation. The present report is No. 25 on this Subtask. It was published in the J. Opt. Soc. Am., Vol. 51, No. 8, Aug 1961.

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Shape of the Red and Green Color Zone Gradients

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Color sensitivity at the boundaries of the red and green zones along the 270° meridian was explored by a cumulative frequency-of-seeing method. The green zone was found to fall in a narrower range and to end closer to the fovea than the red zone. Significant variations of peripheral sensitivity to red were found with all observers. For both red and green, the greatest number of irregularities were found in those curves which extended well into the periphery.

INTRODUCTION

IN a preceding study, Kelsey and Schwartz[1] explored the gradients in the visual field of sensitivity to blue and to yellow. They found that the limits of these color zones do not show sharp cutoffs in sensitivity. Further, the chromatic sensitivity of the region from the point at which the color was reported with high frequency to the point at which it was rarely identified, reveals significant and reliable fluctuations for a given observer with the two colors. These results agree with the implications of the Ferree and Rand,[2] and Wentworth[3] studies which found that the thresholds of chromatic perception, as measured by the luminance necessary to evoke the correct color response, did not follow a regular decrease with distance from fixation but showed great irregularities from fixation to periphery.

In the present study, a frequency-of-seeing procedure, found most adequately descriptive of peripheral sensitivity by Kelsey and Schwartz, has been used to investigate the red and green color-zone limits. With the luminance and size constant, the position in the field was varied systematically. The extent, range, and shape of the gradients were explored with particular reference to the degree to which the red and the green functions follow irregular patterns comparable to those found with blue and yellow stimuli.

APPARATUS AND OBSERVERS

The apparatus was the same Goldmann projection perimeter used by Kelsey and Schwartz. In this instrument the stimulus is projected on a hemispheric screen illuminated by incandescent lamp light. Thus, the stimulus is an additive mixture of light from the background and from the projected beam. The resulting color always has a luminance higher than that of the background and is of less than maximum purity.

Table I specifies the stimuli in terms of the calculated dominant wavelength, purity, and luminance of the mixtures; and gives the size of the stimulus and the luminance of the background. The red stimulus and the green stimulus No. 1, used in the principal experiment, were equated peripherally in brightness. As the table indicates, several conditions were employed to study the green color-zone limit.

Five members of the staff of the laboratory served as observers. Three of these (MC, JK, and AR) observed throughout the experiment. One observer (BH) transferred before completing the series. For the remaining parts, readings on another observer (FD) were taken to provide data on four observers for every experimental condition. All observers had normal color vision.

PROCEDURE

The stimulus was exposed to the right eye of the observer for one second along the lower vertical meridian of the visual field. The positions of the stimulus were presented at intervals of 2° in the region of the color-zone limit. The 0.41° stimulus at higher contrast ratio was shown at 1° discrete intervals. The order of these presentations was randomized within each session.

TABLE I. Description of stimuli and backgrounds.

	Red	Green 1	Green 2	Green 3	Green 4
Dominant wavelength[a]	665 mμ	521.5 mμ	517.5 mμ	511.4 mμ	511.4 mμ
Percent purity[a]	87	70.8	61.5	72	72
Luminance,[a]	4.0 mL	2.67 mL	3.29 mL	1.08 mL	1.08 mL
Wratten filters	No. 33 0.1 N.D.	No. 60 No. 67A	No. 60 No. 67A	No. 60 No. 67A No. 64	No. 60 No. 67A No. 64
Stimulus size	1°	1°	0.41°	1°	0.41°
Field luminance, L_f	1.35 mL	1.35 mL	1.35 mL	0.086 mL	0.086 mL
Luminance ratio $\frac{L_s-L_f}{L_s}$	0.66	0.49	0.59	0.92	0.92

[a] Including background.

[1] Patricia A. Kelsey and I. Schwartz, J. Opt. Soc. Am. 49, 764–769 (1959).
[2] C. E. Ferree and G. Rand, Psych. Review, 26, 16–41 (1919).
[3] Hazel A. Wentworth, Psychol. Monographs XL, 183 (1930).

bility that points of depressed sensitivity may reflect the interposition of gross anatomical structures such as blood vessels has been considered, but there is no evidence of correspondence. However, the over-all decrease in sensitivity with distance from the fovea suggests some relationship to the distribution of retinal elements, probably to functional units sensitive to a specific color. Because the visual field appears much more uniform than a point-by-point exploration shows to be the case, more detailed study of sensitivity is necessary before the pattern of physiological function can be set.